

Formation of HgSe via EC-ALE

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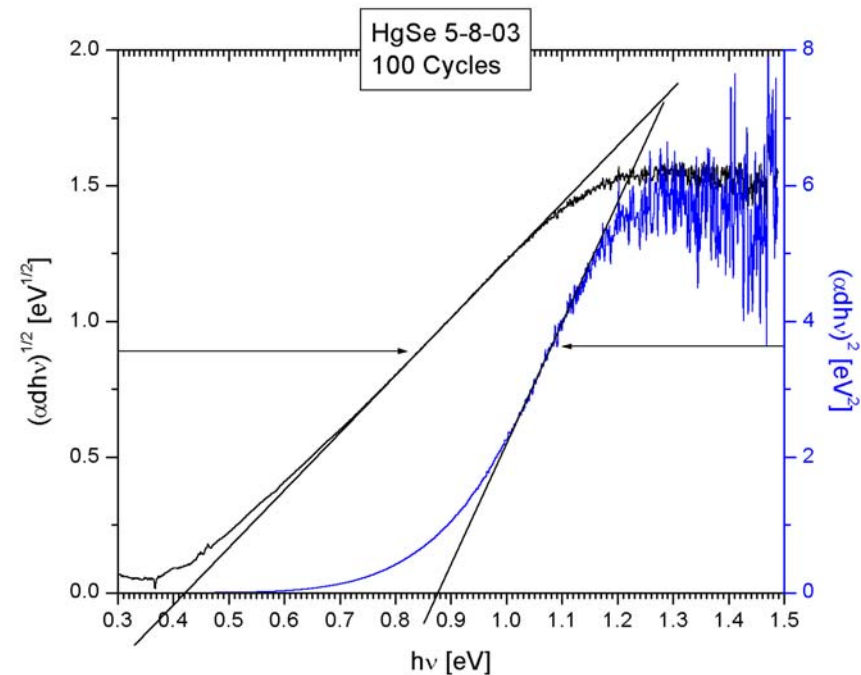
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EC-ALE is the electrochemical analog of atomic layer epitaxy (ALE), or atomic layer deposition (ALD). These are methods used to form compounds an atomic layer at a time, via surface limited reactions. This promotes epitaxy, results in 2D growth, and allows control of thickness at the atomic level.

What: Mercury based II-VI compound semiconductors are the central materials for the formation of infrared detectors and sensors, such as those used in night vision goggles.

So What: Formation of array chips based on thin films is a very expensive process, currently using high temperature liquid phase epitaxy. An electrochemical process would be much less expensive, and provide an added degree of control over composition. As EC-ALE is a room temperature process, deposits could be formed on plastic substrates, making them economic and flexible.

Future: HgSe has been optimized for EC-ALE, and HgTe is close. Combining programs for CdTe and HgTe will result in the formation of Mercury Cadmium Telluride (MCT): $\text{Hg}_x\text{Cd}_{(1-x)}\text{Te}$.



HgSe deposits were characterized using reflection absorption IR measurements, which showed two band gaps, one direct and one indirect, consistent with the literature. Band gap characterization was performed by plotting the square or square root of the absorptivity vs. photon energy. Extrapolation of the linear region to zero provides an estimate of the band gap. Linear graphs based on the square suggest direct band gaps, while linear graphs based on the square root suggest indirect band gaps.

In electrochemistry, surface limited reactions are referred to as underpotential deposition. Underpotentials are used in EC-ALE to grow compounds in a cycle, by alternating the solutions and potentials used to deposit the component elements. The number of cycles performed determines the deposit thickness. EC-ALE was invented by the PI, and has been found to work well for the formation of thin films of compound semiconductors, including II-VI, III-V, IV-VI and other compounds. Recently, programs to form the mercury based II-VI compounds: HgTe, HgSe, HgCdSe and HgCdTe, have all been developed.

Use of EC-ALE allows atomic layer control of the deposition process. In addition, the depositions are performed at room temperature, an important advantage relative to heat based growth methods such as MBE and CVD, normally used to form high quality thin film compound semiconductor structures. For instance, short period superlattices can be formed at room temperature without the interdiffusion encountered in depositions by methods based on heat.

Another advantage of EC-ALE is that deposits are grown an atomic layer at a time. This graph shows thickness as a function of the number of cycles. Each cycle results in a monolayer of the compound, and thus atomic level control over the deposit thickness.

Absorption of photons, by a semiconductor, should start at the band gap, any less energy would not be sufficient to absorb. However, kT must be kept in mind, room temperature will increase the probability of adsorption for photons just below the band gap energies. So if a photon has the band gap energy its probability for adsorption by a valence electron will go up dramatically, but will require a fine state in the conduction band. Thus we need to examine the density of states near the conduction band. For direct band gaps, the approximation is that the DS will increase with the square of the energy, from the conduction band up. On the other hand, in the case of an indirect band gap, a phonon is required as well as the photon. The availability of phonons will determine the adsorption probability. Phonons have a different distribution with energy, and adsorption of the photon will depend on that. From what I understand, phonon densities have a square root dependence on energy. Thus by plotting the square and square root of the absorption date, a straight line dependence will indicate the type of transition. By extrapolating back to zero absorption, we should approximate the energy corresponding to the band gap.

Drum Majors for Science

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Fourth and Fifth grade students studying science at Fourth Street School, Athens, Georgia. This school is 95% minority; the kids are excited about learning science.

DMS is a program designed to bring science into Grammar Schools in the 4th and 5th grades, before they enter Middle School. The idea is to make use of resources at the University (faculty, grad students, undergraduates, and Laboratories) to supplement science education in predominantly minority schools, where teachers are generally scared of science, and the students are at risk to “turn off” to science before they get to Middle School.

Discussions with the Clark County School System, Athens, Georgia, by the P.I. have lead to establishment of a program for predominantly minority grammar schools in the district, which we refer to as “Drum Majors For Science” (DMS). The concept is to promote science at the forth and fifth grade levels, before they enter middle school. DMS includes faculty, graduate students, undergraduate students in the sciences and in education, as well as grammar school teachers from participant schools.

DMS picks predominantly minority schools and assign a participant to visit at least once a semester for a full day. DMS participants will visit the 4th and 5th grade classes, individually, in order to keep the student teacher ratio low, and maximize the benefit for at risk kids. A presentation on a topic, designed to help and accentuate the science curriculum for that school, is give to each class. The presentations involve a power point slide show, a few germane demonstrations, and simple experiments for the students. Most important will be time set aside to talk with the students and answer questions. These kids are full of questions and ideas, most of which their teachers are unable or even scared to answer. Common themes are emphasized repeatedly, such as the periodic table, with the intent of getting the students to think in terms of atoms, molecules and reactions, as an example. As a minimum, the children will see the same scientist at least four times before they go on to middle school. The whole point is to have the opportunity to learn from, talk to, and get to know a scientist.

The size of the program will be a function of the number of participants. Once the local school district has been subscribed, the next targets will be intercity schools in Atlanta.

Note: The curriculum for DMS is under construction. Vicki Stickney, MS. Chemistry, a teacher for remedial math and English, is helping with DMS. Both John and Vicki Stickney have been working with classes at Fourth Street school, developing curriculum ideas which are being used in DMS. The pictures in this slide are from two different days, in two different classes. The only teacher shown is Miss Varnum, right picture, right side, the rest of the people in the figures are students in her class